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Office of the Secretary
Federal Communications Commission
445 12th Street, TW-A325, S.W.
Washington, D.C. 20554

Ladies and Gentlemen:

Reference your Public Notice DA99-1049 and DD99-1135 soliciting comment on wireless E911 Phase II ALI requirements. We became aware of your solicitation on June 16th and filed preliminary comment on June 17th (reference our letter dated June 17th). We would like to offer a continuance of our comments regarding *Methodologies for Determining ALI Accuracy.*

We are recommending that the Commission adopt a statement for location accuracy consistent with current practice in search and rescue operations throughout the U.S. The current practice is to report estimated transmitter location with an associated region of uncertainty. The uncertainty region provides a measure of credibility in the location estimate and is used to define a search area. As a strawman, we are suggesting that the adopted location accuracy specification be stated as follows:

> *"Wireless providers shall provide the location of a mobile 9-1-1 caller in geographical coordinates with an associated region of uncertainty based on circular error probability (CEP) at the 90% level. For 67% of all calls, the CEP shall have a radius of 125 meters or less* ***and*** *must contain the 'true' location of the mobile transmitter"*

A CEP based location accuracy statement is attractive for several reasons:

- It is technology neutral and will apply to either network or handset based solutions
- It is based on well established statistical and sampling procedures that facilitate verification of compliance
- It exploits the insight and experience gained over the past 50 years in the evolution of emergency search and rescue operations
- It takes into account the existence of outliers in the data and mitigates their adverse effect
- It takes into account the fact that some 9-1-1 calls will produce no location estimate due to lack of coverage, propagation conditions, etc.

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In terms of implementation and compliance verification, we suggest that each wireless provider makes theoretical predictions of location accuracy throughout its coverage area. These predictions should be characterized by appropriate 90% CEP contours using well known techniques such as described by Foy[1] for AOA, TDOA or TOA network based location systems, or by Enge and Misra[2] for GPS handset based location systems. The theoretical performance predictions can be validated at critical points throughout the coverage region with carefully planned drive tests. At selected points, repeated location measurements can be made in 1 minute "cold start" intervals and the geographical coordinates used to define 90% CEP parameters. With appropriate sampling at selected points throughout the coverage region, the theoretical contours can be adjusted as required.

The validated CEP performance contours provide a mechanism for compliance verification. We recommend that the region of coverage be divided by a system of square grids. The grid system may be as small as 125 meters on each side. Each grid point is evaluated to determine whether or not the 90% CEP radius is 125 meters or less and the search region contains the "true" transmitter location. The ratio of positive responses to the total number of grid points should be 0.67 or greater. The grid includes those regions where a location estimate should have been generated but was not.

We have included example plots of CEP location analyses for various network based solutions. A typical deployment of base stations has been assumed throughout the Metropolitan San Antonio, Texas area. In Figure 1, we considered a network of AOA sensors whose angular accuracy was ± 1.5 degrees bearing standard deviation. The radio horizon for each base station was 5 km. We assumed that a location could be estimated using at least two observed bearings. Many systems require at least three bearings to obtain reasonable accuracy.

A CEP location analysis for the same base station deployment is shown in Figure 2 for a TDOA network based location system. In this case we assumed that the time base in the TDOA system had an accuracy of $\pm 0.5 \mu sec$, and detection at three base stations was required to produce a location estimate. Comparing Figure 2 with Figure 1, it is clear that the TDOA performance is more accurate in the downtown area, but the overall coverage is somewhat reduced. Figure 3 illustrates the performance of a combined AOA/TDOA system. This system provides greater coverage with enhanced accuracy.

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[1]W.H. Foy, "Position-location solutions by Taylor-series estimation," *IEEE Trans. Aerospace and Electronic Sys.*, vol. AES-12, no. 2, pp 187-194, March 1976.

[2]P. Enge and P. Misra, "Special issue on GPS," *Proc. IEEE,* vol. 87, no. 1, January 1999.

The results of compliance verification analysis is shown in Figure 4 for an AOA/TDOA system. We have computed a cumulative distribution function (CDF) defined by the ratio of grid points to total number of grid points whose CEP error is equal to or less than the value given on the abscissa. A critical region is characterized by the rectangle whose sides are defined by 67% and 125 meters. In this case approximately 95% of the grid points result in a location accuracy of 125 meters or less.

In summary, we would emphasize two important points related to our recommendations. First of all, the use of repeated trials to develop an experimental data base for CEP validation may at first glance appear to be a formidable undertaking; however, computer instrumented mobile laboratories routinely used by Southwest Research Institute and by other organizations, permit the acquisition of large experimental data bases with minimal human interaction and very low cost. Several handsets could be operated in parallel to accelerate the data acquisition process. Also this would permit us to evaluate the effect of handset orientation and to enhance frequency coverage. Secondly, it is crucial that the experimental design provide thorough coverage of the entire wireless service area. For example, a validation measurement campaign for the CEP predictions in Figure 1 would sample relatively few points in the red and yellow areas (where there is little change in performance), but would sample more densely in the color transition regions of red/yellow and yellow/green. Clear definition of the transition regions permits us to make appropriate adjustments in the theoretical predictions to obtain agreement with the experimental data. A thorough and accurate validation ensures the integrity of the compliance verification process.

In these comments, we have excluded the mathematical rigor involved in the definition of the concepts and have focused primarily on the presentation of principle issues. We appreciate consideration of our comments by the FCC and would welcome the opportunity to discuss these issues in greater detail at your convenience. If we can provide additional information, please contact Dr. Richard Johnson at 210/522-2765 or by email at *rjohnson@swri.org*.

Sincerely,

Terry C. Green, PE
Vice President

Encl.

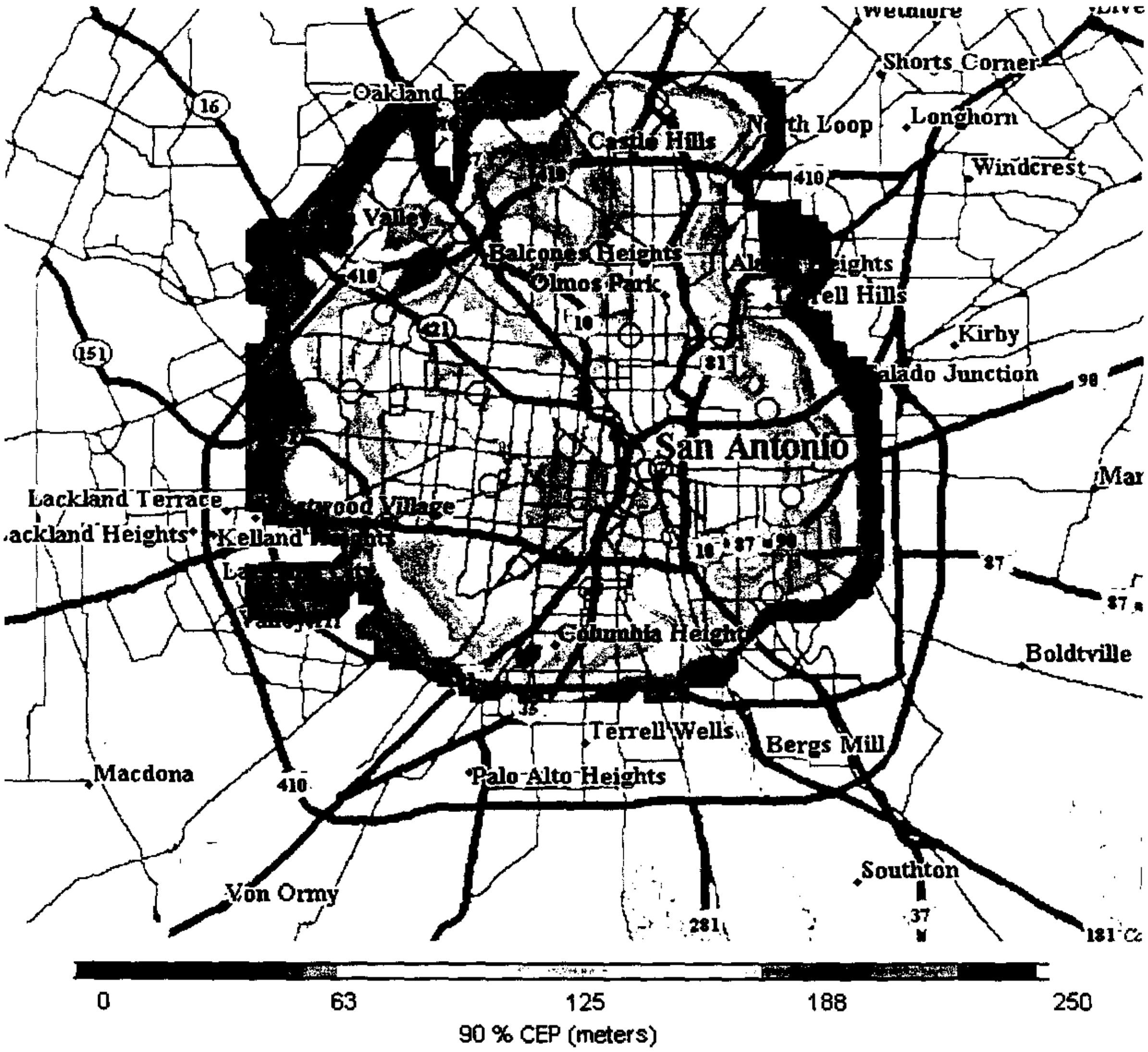

Figure 1. CEP Location Analysis for AOA Network Based System

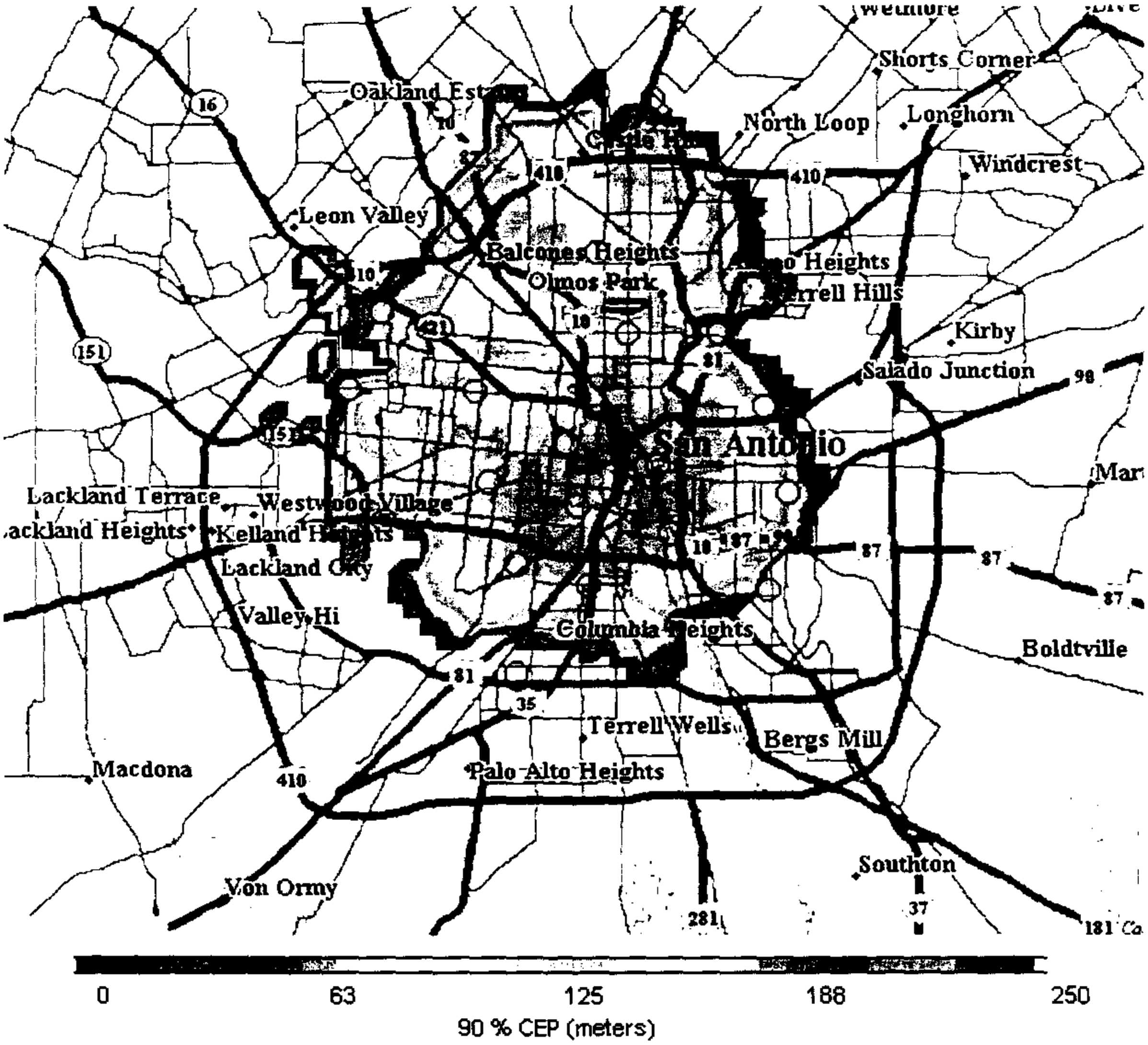

Figure 2. CEP Location Analysis for TDOA Network Based System

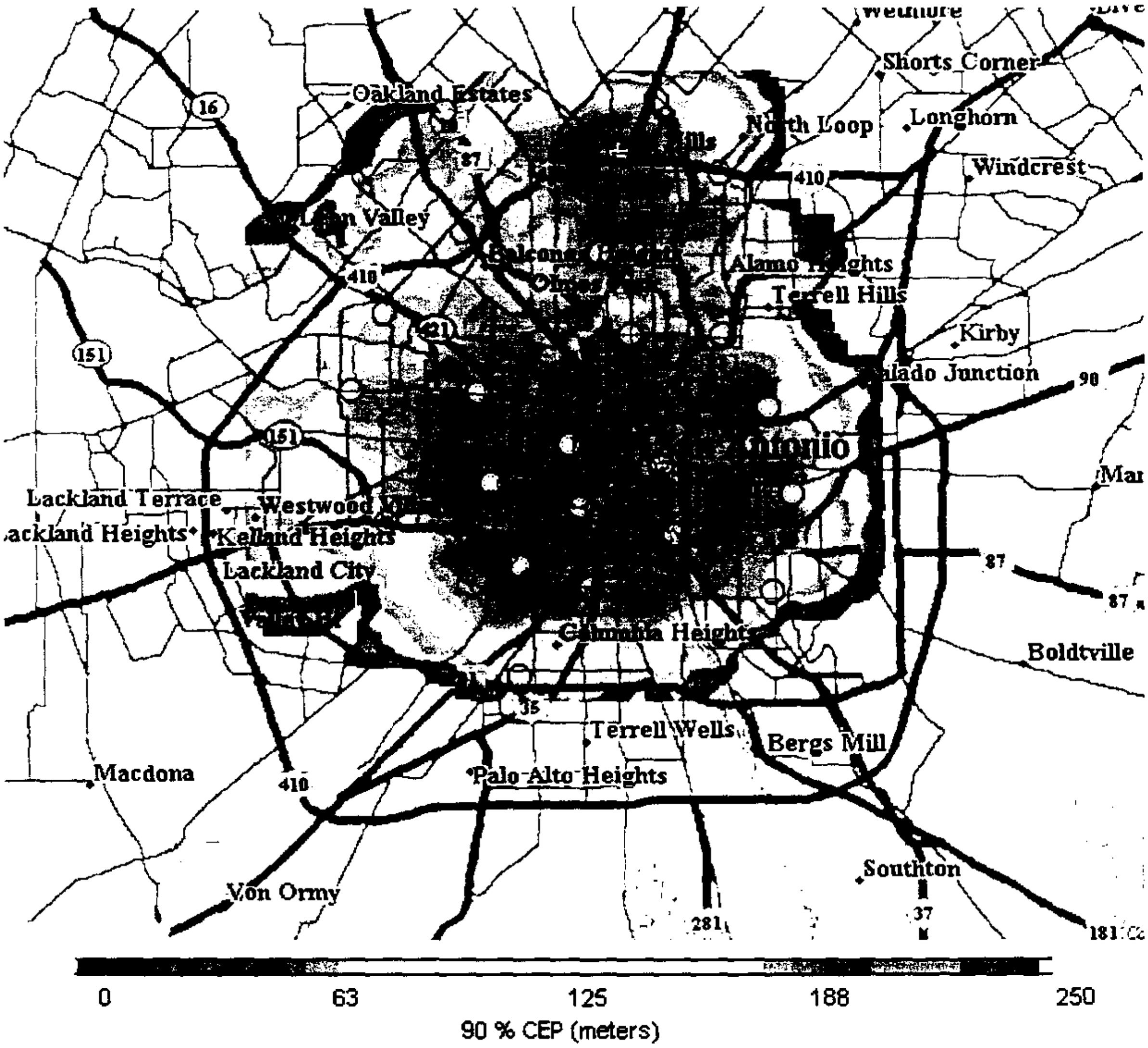

Figure 3. CEP Location Analysis for combined AOA/TDOA Network Based System

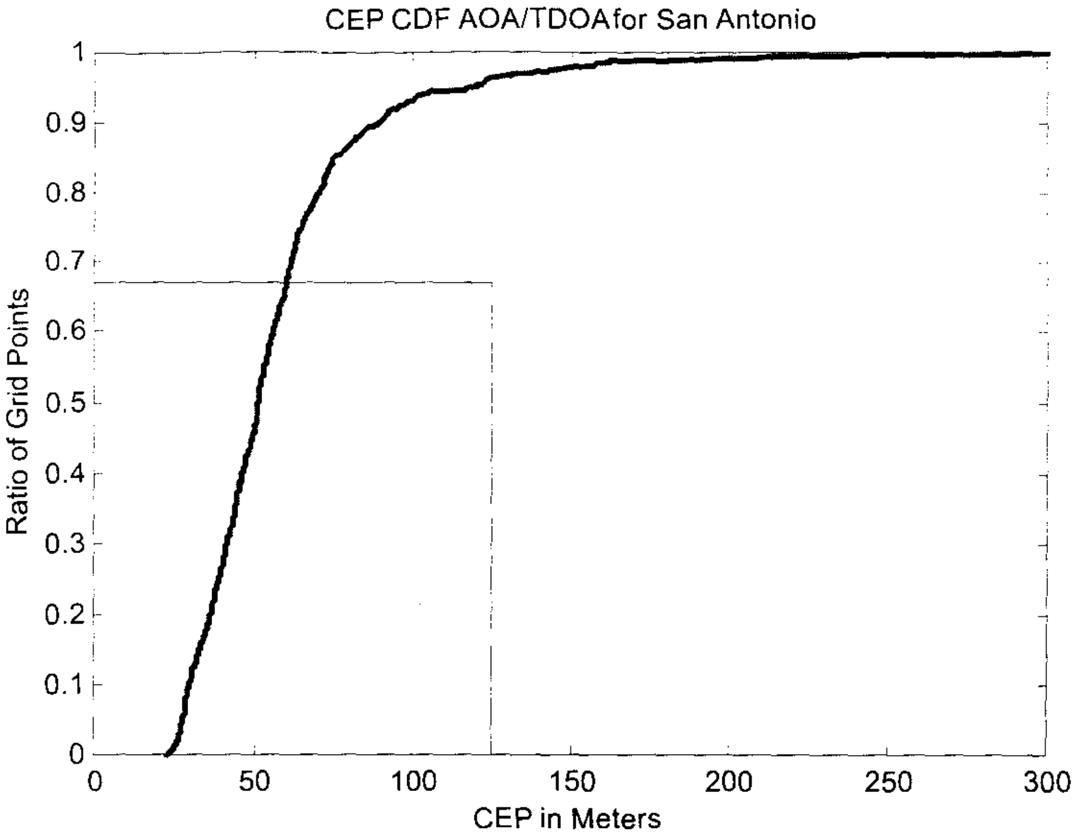

Figure 4. Compliance Verification Analysis for Composite AOA/TDOA Location System